Patent Application of

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for

TITLE: COMPOSITE FINGER FLEXION GLOVE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is entitled to the benefit of Provisional Patent Application Serial No. 60/268,985, filed February 15, 2001.

BACKGROUND—FIELD OF INVENTION

This invention relates to the use of external devices to facilitate the rehabilitation of an injured human hand.

BACKGROUND—DESCRIPTION OF PRIOR ART

The complexity of the human hand makes it susceptible to stiffness and decreased mobility following an injury. Occupational therapists and physical therapists provide stretching, exercises, and activity to help the injured individual regain range of motion of the fingers. Improved range of motion of the fingers ultimately results in improved strength and functional use of the injured hand. Each of the fingers of a human hand has three joints, a distal

interphalangeal (DIP) joint that is the joint closest to the fingertip, a proximal interphalangeal (PIP) joint that is the joint next closest to the fingertip and the metacarpalphalangeal (MP) joint at the connection of the finger to the hand. All of the finger joints must flex simultaneously in order to achieve full grasp of an item. For example, the fingers of each hand must wrap around a golf club handle in a pattern of simultaneous flexion of the MP, PIP, and DIP joints in order to create a firm grip. The grip becomes weaker if one of the joints is not flexed. Imagine trying to swing a golf club with flexion of the PIP and DIP joints of the fingers but not the MP joints. Simultaneous flexion of the finger joints is also required for screwdriver use, firmly gripping the steering wheel of a vehicle, using a large spoon to stir cake batter, and on and on. Simultaneous flexion of the MP, PIP, and DIP joints of a finger is called composite finger flexion. An individual displays full composite flexion of the fingers when the hand is in a fisted position.

Over the span of decades there have been numerous devices used to facilitate the rehabilitation of hand injuries. These devices fall into the category of rehabilitation orthotics and are generally referred to as splints. Hand therapy specialists routinely use hand and/or finger splints to position the injured hand or finger in a way that: provides protection, prevents further deformity, or facilitates increased range of motion. Splints that hold a body part in a set position are referred to as static splints. Static splints are generally used to provide protection or prevent further deformity. Splints that apply a force to create or allow movement of a body part are called dynamic or static progressive splints. For example, a dynamic splint may stabilize the wrist and hand while using a rubber band to place a dynamic force on one or more fingers. Dynamic splints are often used to facilitate increased functional movement by applying a force to the stiff or injured part over an extended period of time. In Clinical Mechanics of the Hand, Dr.

Paul Brand and Anne Hollister have identified the importance of gentle continuous stretch to lengthening of tissue in the injured hand.[1] The force is usually applied by an elastic component of a spring or rubber band. There are several existing devices that focus on increasing finger flexion, but they are limited by a number of factors:

(a) There is a "finger flexion glove" that is currently available in most hand rehabilitation catalogs. This device can be described as a lightweight glove with a wrist strap and an eyelet on the end of each finger. Rubber bands are attached to the eyelets in the fingertips of the glove and then to a hook on the glove wrist strap. The tension of the rubber bands creates an elastic tension that pulls on the glove, bending the fingers into flexion. The "finger flexion glove" is effective in facilitating partial flexion of the fingers, but does not accomplish full composite flexion of all of the finger joints. The arrow in prior art Fig. 8 identifies the direction of force at the end of a finger in a "finger flexion glove". The direction of the force and the orientation of the hand prevent simultaneous bending of all of the finger joints. The ability to adjust the tension or force provided by the "finger flexion glove" is limited. The only way to adjust the forces on the fingers is to change the size of the rubber band or change the location of the rubber band attachment.

(b) Another arrangement is referred to as the "Biodynamic™ flexion/extension system (U.S. Patent No. 5,413,554) ". This system is most often used in conjunction with a static thermoplastic wrist splint fitted to the wearer's forearm. The forces of this system are applied to a line that connects to two individual finger straps. The fingers are flexed as the line is pulled and attached to the hand or wrist. This arrangement is useful, but requires two separately attached straps for each finger and is somewhat difficult to adjust. There is also a

mechanical disadvantage to the arrangement, which requires a significant force to pull the finger into full composite flexion. The arrows in prior art Fig. 7 show the direction of pull on the finger straps.

(c) Another arrangement is primarily a static progressive system including a circumferential wrist wrap and other attachments described in U. S. Patent No. 5,447,490. It is useful to note that the three types of finger strapping arrangements provide a static flexing force to the fingers, not a dynamic one. One set of straps is used to bend the MP and PIP joints simultaneously. The second set of straps is used to bend the MP, PIP and DIP joints simultaneously. The third set of straps are used in conjunction with rubber band attachments to allow for exercise of the fingers, but do not provide a dynamic composite bending force. The disadvantages of this arrangement are evident. The system is complex and requires the use of many individual pieces for each finger. The bending forces applied to the fingers are static, the only dynamic component of the system is provided for exercise. The purchase of several different systems for each phase of finger movement can be costly.

(d) None of the above examples has a system that applies a dynamic force of simultaneous composite finger flexion to each of the fingers of an injured hand.

(e) The adjustment of each of the above methods is limited and cumbersome.

(f) None of the above devices provide a support component to the volar (palm side) surface of a finger or fingers allowing them to wrap around a bar in a normal gripping pattern. Fig. 9 shows the volar placement of a crossbar at the end of a finger. As the crossbar is rotated by the forces shown as arrows, the finger will progressively wrap around it as the rehabilitation continues.

(g) Other devices usually involve the use of a static splint and arrangements of finger loops, lines, and adjustment mechanisms that are cumbersome and difficult to don and doff.

SUMMARY

In accordance with the present invention a composite finger flexion glove is used to apply a dynamic force of composite finger flexion to each of the fingers of an injured hand in a way that is easily adjustable, is easily donned and doffed, and facilitates rehabilitation of an injured hand to a normal grip pattern.

Objects and Advantages

The present invention has been specifically designed to provide dynamic forces that act on the joints of the fingers of the hand in a composite flexion pattern. It is important to apply force to all of the finger joints in a composite pattern to recreate full functional use of the fingers of the injured hand. The arrangement consists of a glove that has attached loop fastener tabs at the end of each of the four finger locations. The loop fastener tabs are matched with a crossbar that has hook fastener material attached to it in a manner typically used for mated loop and hook fasteners in the industry. The crossbar is shaped to promote comfortable placement of the fingertips of the hand and provide secure attachment of the glove to the crossbar. The fingers of the hand are curled or wrapped around the crossbar by its' torsion forces and are held there by the glove. The crossbar provides a volar support component at each of the selected fingers. The crossbar has an outrigger attached to it. The outrigger transfers the force of the elastic component to the crossbar that in turn applies the force to fingers of a wearer's hand. One end of the elastic component is attached to the outrigger and the other end is attached at the wrist of the wearer. The outrigger transmits the dynamic force of the elastic component into a torsion force

that is applied to the crossbar at one of its ends. The torque is transmitted to the MP, PIP, and DIP joints of the hand through the combined action of the glove and the crossbar. The arrangement is adjustable in three ways; the placement of the loop fastener tabs on the crossbar may be individually adjusted for each finger, the orientation of the outrigger may be selectively fixed at its connection to the crossbar, and the size of the elastic component may be varied. The wearer may easily make adjustments without the use of special tools and has the ability to easily refine the torque adjustment of the crossbar for comfort. The entire arrangement is easily donned and doffed. The wearer puts the glove on, adjusts the outrigger to the desired position and attaches the elastic component to the wrist or hand. Accordingly, besides the objects and advantages of the composite finger flexion glove described above, several objects and advantages of the present invention are:

(a) To provide the use of a composite finger flexion glove that applies a dynamic force of simultaneous composite finger flexion to each selected finger in a way that is easily adjustable.

(b) To provide the use of a composite finger flexion glove that applies a dynamic force of simultaneous composite finger flexion to each selected finger in a way that is easily donned and doffed and is easily adjustable.

(c) To provide the use of a composite finger flexion glove that applies a dynamic force of composite finger flexion to each selected finger in a way that is easily donned and doffed, is easily adjustable, and does not require the use of several individual components that are awkward and cause increased expense.

(d) To provide the use of a composite finger flexion glove that applies a dynamic force of simultaneous composite finger flexion to each selected finger of an injured hand.

(e) To provide the use of a composite finger flexion glove that provides for adjustment in three different ways, and is easily adjusted while worn.

(f) To provide the use of a composite finger flexion glove that applies a volar support component to each of the selected fingers as the dynamic composite flexion force is applied.

(g) To provide the use of a composite finger flexion glove that can be easily donned and doffed by placing the glove on an injured hand and adjusting the other components to the desired force.

DRAWING FIGURES

Fig. 1 shows a view of the composite finger flexion glove when worn.

Fig. 2 shows a view of the glove, tabs attached to the glove fingertips, and the wrist strap.

Fig. 3 shows a view of the crossbar and outrigger.

Fig. 4 shows an end view of the crossbar where one end of the outrigger fits for adjustment.

Fig. 5 shows a cross sectional view of the crossbar where the ends of the outrigger fit into place.

Fig. 6 shows a cross sectional view of the crossbar in the center section, where no hole is required for the outrigger placement.

Fig. 7 shows a view of prior art Biodynamic™ flexion/extension system.

Fig. 8 shows a view of a finger in a prior art “finger flexion glove”.

Fig. 9 shows a view of the composite finger flexion glove crossbar at the end of a fingertip.

Reference Numerals In Drawings

11 Elastic Component	20 Glove

21a, 21b, 21c, 21d Loop fastener tabs

22 Wrist strap

30 Outrigger

40 Crossbar

41 Notch

42 Hole

43 Hook fastener attachment

DESCRIPTION --- Figures 1-7

A preferred embodiment of the composite finger flexion glove is shown in Fig. 1. The glove **20** is made of material strong enough to transfer the required force to the fingers while flexible enough to allow finger movement into the desired position. Loop fastener tabs **21a**, **21b**, **21c**, and **21d** are attached to the ends of the finger portions of the glove **20**. The crossbar **40** has hook fastener material **43** attached to both sides for interface with the loop fastener tabs **21a**, **21b**, **21c**, and **21d**. When the glove **20** is worn and the tabs **21a**, **21b**, **21c**, and **21d** are attached to the crossbar **40**, the rotation of the crossbar **40** creates a flexion force that is transferred to the finger joints of the hand. The rotation of the crossbar **40** is achieved by adjusting the outrigger rod **30** into the desired position and attaching the elastic component **11** from the outrigger rod **30** thence around the hand or wrist. Fig. 2 shows the glove **20**, attached loop fastener tabs **21a**, **21b**, **21c**, **21d**, and the wrist strap **22**. Fig. 3 shows the shape of the outrigger **30** that is made of material strong enough to apply the desired torsion to the crossbar **40** yet flexible enough to allow easy placement into the ends of the crossbar **40**. Fig. 1 shows the anticipated placement of the elastic component **11** that can be of varied size and shape depending upon the desired tension. Fig. 3 shows the crossbar **40** with the outrigger rod **30** inserted into holes **42** at the ends. The holes **42** (shown in Fig.4 and Fig. 5) at each end of the cross member **40** are sized to accept the ends of the outrigger **30** and provide ample clearance to allow free rotation of the outrigger

30. Fig. 4 is an end view of the adjustable portion of crossbar **40**. The notches **41** at one end of crossbar **40** are provided to selectively restrict rotation of the outrigger **30** relative to the longitudinal axis of the crossbar **40**. The notches **41** are sized to accept the circular outrigger **30** for easy placement. Adjustment of the position of the outrigger **30** is accomplished by pulling it out at the notched end of the cross member **40**, rotating it to one of the desired notches **41**, then seating it in one of the desired notches **41**.

Advantages

From the description above, a number of advantages of the composite finger flexion glove are apparent:

(a) The device applies a dynamic force of simultaneous composite finger flexion to each of the selected fingers of an injured hand.

(b) The glove can be easily donned and doffed.

(c) The crossbar provides a volar support component to the device, facilitating the stretch of the fingers into a normal gripping pattern.

(d) There are three ways that the device may be adjusted to the needs of the wearer.

1) The tabs attached to the glove may be placed at varied locations on the crossbar.

2) Increasing or decreasing the dynamic force on the fingers may be achieved by changing the selected orientation of the outrigger in the notches at the end of the crossbar.

3) The size and type of elastic component may be changed to either decrease or increase the dynamic force applied to the outrigger.

(e) The required components are simple and can be easily manufactured.

(f) The force lever arm of the outrigger is sufficiently long to provide a generous amount of torque at the crossbar with very little applied dynamic force by the elastic component.

Operation – Figures 1-7

The manner of use of the composite finger flexion glove is easy to understand and adaptable to the needs of the wearer. The glove **20** is attached to the crossbar **40** by the loop fastener tabs **21a**, **21b**, **21c**, and **21d**. The outrigger **30** will normally be in place at the ends of the crossbar **40**. The glove **20** is placed on the injured hand and the wrist strap **22** is fastened around the wrist. The outrigger **30** is rotated to the desired position and seated in one of the desired notches **41**. The elastic component **11** is normally attached to the outrigger **30** before the glove **20** is donned and then attached to the hand or wrist as the final adjustment step. To remove the composite finger flexion glove the elastic component **11** is first removed from the wrist, then the glove **20** is removed, still having the crossbar **40** and the outrigger **30** attached. The next time the composite finger flexion glove is worn it should require only minor adjustment. The dynamic force of the elastic component **11** is transferred through the outrigger **30** to the crossbar **40**. The torsion force at the end of crossbar **40** is transferred to each finger's end by the tab attachments **21a**, **21b**, **21c**, and **21d**. The force at the ends of the wearer's fingers is a torsion force that is transferred to the other joints of each finger, creating composite flexion forces. The ability of the fingers to wrap around the crossbar is determined by their stiffness, as their flexibility and range of motion increase they will flex into a grip pattern around the crossbar **40**.

Conclusion, Ramifications, and Scope

The composite finger flexion glove provides a simple arrangement for the rehabilitation of the fingers of an injured hand. It is easily donned and doffed, provides three methods of adjustment, and provides a primary means of adjustment that is easily accomplished while the composite finger flexion glove is worn. It applies a dynamic composite flexion force to the fingers, has a volar support component for each finger, encourages a normal gripping pattern as fingers gradually begin to wrap around the crossbar, and is comprised of components that are easily manufactured.

Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention. For example, the covering of the hand need not be a glove, but could be another arrangement of material that transfers the forces in a similar manner. The outrigger may be of a different form and shape than the one shown. The crossbar shape and method of transfer of the forces may be varied to accomplish the same end result. The entire crossbar and outrigger component may be made smaller to be used for an individual finger or any number of fingers. The elastic component may be replaced with a static or static progressive component.

Thus the scope of the invention should be determined by the appended claims and their legal equivalents, rather than by the examples given.